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PRACTICAL METALLURGY AND ASSAYING

A TEXT-BOOK FOR THE USE OF TEACHERS, STUDENTS,
AND ASSAYERS

By ARTHUR H. HIORNS

HEAD OF METALLURGY DEPARTMENT, BIRMINGHAM MUNICIPAL TECHNICAL SCHOOL

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To
PROFESSOR W. CHANDLER ROBERTS-AUSTEN, K.C.B., F.R.S.,

IN RECOGNITION OF HIS EMINENT SERVICES IN DEVELOPING
THE TEACHING OF METALLURGY,
AND IN APPRECIATION OF HIS KINDNESS
AND OF

HIS UNFAILING SYMPATHY WITH ALL STUDENTS,
THIS BOOK IS DEDICATED
BY HIS OLD PUPIL

THE AUTHOR.

PREFACE.

THE aim of the book is to teach the principles of Practical Metallurgy by means of a series of experiments, which have been chosen, partly on account of their practical utility, and partly as affording a valuable course of instruction for students preparing for, or engaged in metallurgical pursuits.

The first part is specially intended for persons having little or no knowledge of the scientific principles underlying the subject: it will also lay a foundation for the study of the higher branches of any particular section of Metallurgy.

The second part consists of a treatise on Assaying by "dry" methods and is intended, in conjunction with the first part, to meet the wants of students desirous of making a complete study of the subject of dry assaying.

The third part deals with wet methods, and is designed to form a suitable course of study for students who have mastered the principles involved in the first and second parts, though it is hoped that the information will be useful to many who, possessing only a limited knowledge of the subject, wish to practise methods of analysis and assaying beyond their own particular branch. For convenience of study, this part is treated under three

heads—(1) Division of metals and acids into groups, with methods of separating and estimating each constituent; (2) Analysis of various ores, fluxes, slags, products and alloys; (3) Volumetric methods of assaying.

The Author has devoted special attention to the analysis of iron and steel, explaining the most trustworthy methods with which he is acquainted; but simple and rapid methods by which approximate results may be obtained have not been overlooked. Great care has also been exercised in giving detailed directions for the assay of gold, silver, copper and other useful metals.

Although the work mainly consists of a number of examples for the student to work out in a scientific manner, information is also given for the guidance of the operator in his manipulations and in explanation of the character of the bodies which should be obtained. A chemical equation is given where necessary, to show the changes which occur and to enable a calculation to be made for finding the quantity of a flux, reducing agent, etc., requisite in each case, and to verify the weight of the product obtained.

As Electro-Metallurgy now forms an important branch of this subject and is probably destined to still greater expansion in the near future, it has been thought advisable to introduce a few elementary experiments illustrative of its employment in connection with metals, such experiments forming the groundwork of the course of practical instruction given in the Electro-Metallurgical Laboratory of the Birmingham Municipal Technical School.

The short description which is given of a metallurgical

laboratory with its necessary fittings and appliances, will, it is thought, prove useful in the formation of new classes.

The Author cordially acknowledges the assistance he has received in the preparation of this work from Dr. Percy's Manuals on Metallurgy; Fresenius' Quantitative Analysis; Watts' Dictionary of Chemistry; Mitchell's Assaying; Crookes' Select Methods in Chemical Analysis; Sutton's Volumetric Analysis; Gruner's *Traité de Métallurgie*, and various papers in the pages of *Iron, Engineering* and *The Chemical News*. He is specially indebted to Professor Chandler Roberts-Austen, the notes on whose lectures at the Royal School of Mines form the basis of the experiments quoted, and whose kindly help was invaluable in the inauguration of the School of Metallurgy with which the author is associated. To Mr. G. C. Marks, C.E., for executing the drawings; to Mr. T. J. Baker for contributing the section on Electro-Metallurgy; and to Mr. Enoch Evans for the section on Gas Analysis, grateful acknowledgments are also tendered.

October 1888.

PREFACE TO SECOND EDITION.

ADVANTAGE has been taken of the issue of another edition to introduce some new matter, and also to make certain alterations which have been suggested by the increased experience of the last three years. The Author gratefully acknowledges his indebtedness to Mr. J. H. Stansbie for his kindness in reading the proofs.

BIRMINGHAM MUNICIPAL TECHNICAL SCHOOL,
February 1892.

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PART I.

INTRODUCTORY.

§ 1. Metallurgy in its fullest sense treats of metals in their natural state, the mode of their extraction from the ore, and their application to various manufacturing purposes.

It is a chemical art requiring a knowledge of the laws of Chemistry, and a metallurgical training is not complete without some acquaintance with that special branch known as Analytical Chemistry, by which the amount of every individual constituent of a compound may be determined. In fact, Metallurgy is the application of Chemistry, Physics and Mechanics to the treatment of metalliferous materials with a view to the extraction of the metals and their conversion to workable forms.

To certain groups of metals different modes of treatment are applicable, which vary from each other as much as the metals do themselves. All these methods rest on general principles, and in many cases the same reagents, the same apparatus, and the same processes are employed.

§ 2. The term metal has long been applied to a certain number of the chemical elements which have well-defined physical characters in common, by which they may be readily recognised. Gold and silver were formerly regarded as the types, on account of their high specific gravity, brilliant lustre, and superior conductivity for heat and electricity. But these properties are by no